Production and Soil Responses to Two Integrated Crop and Livestock Strategies in the Southern Piedmont USA

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Questions

To graze or not to graze?
- Grazing could diversify income.
- Will grazing compact soil?
- Should cover crops be left intact as surface mulch or can they by effectively grazed without harm?

To till or not to till?
- Conservation tillage known to benefit soil.
- If not tilled, will soil be compact?
- Can crops be successfully no-till planted without sufficient residue?

Summer grain–winter cover crop or winter grain–summer cover crop?
- Summer offers greatest maximum yield / profit potential due to warm temperature, but is dependent upon variable precipitation.
- Winter-spring cropping has reliable precipitation, but yield / profit potential may only be moderate.
- Will occasional years of maximum yield in summer be more profitable than consistent, moderate yield in winter-spring?

Methods

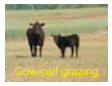
- Set of 32 plots previously in tall fescue for 20 yr on Cecil sandy loam in Watkinsville GA
- Treatments (4 replications each) were a factorial of:
  - Cropping system
    - –summer grain + winter cover (SGWC)
    - –winter grain + summer cover (WGSC)
  - Tillage management
    - –conventional tillage (CT)
    - –no tillage (NT)
  - Cover crop management
    - –grazed by cattle (GR+, 0.5 ha)
    - –ungrazed (GR-, 0.2 ha)
- All crops received topdressing of ca. 40 kg N/ha
- Crop yield from entire paddock with combine
- Forage yield from ca. 2 m^2 areas in ungrazed plots
- Cattle weight after no water for 16 h
- Yearling steers during Year 1, cow/calf pairs during Years 2 and 3
- Mean results from 2002/03, 2003/04, and 2004/05
- Soil collected from 5 to 8 cores (4-cm diam) in a plot on a yearly basis
  - Soil organic C and N (dry combustion)
  - Microbial biomass (CHCl3 fumigation-incubation)
  - Bulk density (weight / volume of 5-8 cores)
  - Water infiltration (30-cm ring, 1 hr, 2 rings/plot)
  - Penetration resistance (strikes of 2-kg hammer, 0.74 m onto a 2-cm-diam cone and 30° tip)
  - Soil water content (time-domain reflectometry)

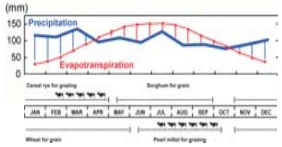

Seed drilling for CT


Seed drilling for NT


Roller/crimper for NT


Mowing cover crop for CT


Cow/calf grazing




Combine harvest


Grazing rye for 26-49 d (March-April)
Summer grain - winter cover crop


Sorghum after rye


Wheat after millet


Grazing pearl millet for 50-77 d (Jul-Sep)
Winter grain - summer cover crop


Ungrazed rye
Grazed rye


Grazed millet
Ungrazed millet

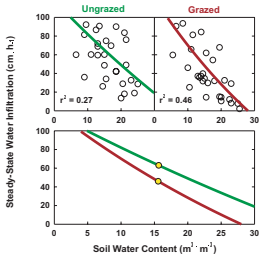
--- Production Responses ---

<, <<, and <<< indicate significance at $p = 0.1$, $p = 0.01$, and $p = 0.001$, respectively.

To graze or not to graze?

Yield Component	Ungrazed kg ha^{-1}	$		Grazed kg ha^{-1}	$
Sorghum / rye (Summer grain / winter cover)					
Cover crop biomass	6537	↻	>>>	397	↻
Cattle gain	0	0	<<<	277	485
Grain	1757	141		1609	129
		[141]			[614]
Wheat / pearl millet (Winter grain / summer cover)					
Cover crop biomass	8505	↻	>>>	722	↻
Cattle gain	0	0	<<<	305	534
Grain	2184	240	<	2424	267
		[240]			[801]

Assuming sorghum grain at $0.08/kg, wheat grain at $0.11/kg, cattle at $1.75/kg

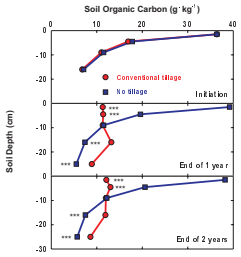


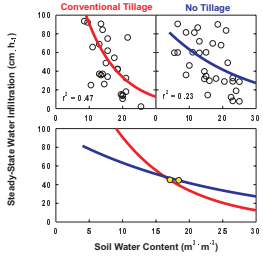
---------- Soil Responses ----------

Depth	Initiation GR-	Initiation GR+	End of Yr 1 GR-	End of Yr 1 GR+	End of Yr 2 GR-	End of Yr 2 GR+
	Soil Bulk Density (Mg m^{-3})					
Conventional tillage						
0-3	1.12	1.07	1.12	1.10	1.16	1.17
3-6	1.48	1.42	1.35 >	1.28	1.31	1.34
6-12	1.57 >>	1.52	1.43	1.43	1.40	1.43
12-20	1.60 >>	1.55	1.45	1.44	1.52	1.49
No tillage						
0-3	1.10	1.10	0.97	0.99	0.96	1.04
3-6	1.43	1.46	1.37	1.38	1.40	1.40
6-12	1.54	1.53	1.50	1.52	1.51	1.54
12-20	1.57	1.58	1.52	1.57	1.54	1.54
	Surface Residue N (kg ha^{-1})					
CT	82	77	9	6	21	< 51
NT	82	74	120	111	214	>> 158

To till or not to till?

Yield component	Conventional Tillage		No Tillage
Sorghum / rye (Summer grain / winter cover)			
Sorghum grain (Mg ha^{-1})	1.66		1.70
Sorghum stover (Mg ha^{-1})	3.07	<<<	5.29
Unharvested rye (Mg ha^{-1})	6.04	<<<	7.03
Cattle gain (kg ha^{-1})	204	<<	350
Wheat / pearl millet (Winter grain / summer cover)			
Wheat grain (Mg ha^{-1})	2.36		2.25
Wheat stover (Mg ha^{-1})	1.27	<	1.42
Unharvested millet (Mg ha^{-1})	7.41	<	9.60
Cattle gain (kg ha^{-1})	286		324





Summer grain / winter cover (SGWC) or winter grain / summer cover (WGSC)?

Yield component	SGWC	WGSC
Mean yield (Mg ha^{-1})		
Grain	1.68	2.30
Stover	4.18	1.35
Cover crop	3.47	4.61
Cattle gain	0.28	0.30
Coefficient of variation (%)		
Grain	96	3
Stover	47	21
Cover crop	29	48
Cattle gain	60	50

Soil carbon stock (Mg ha^{-1}) at the end of 2 years:

	Summer Grain–Winter Cover: Conv Tillage		Summer Grain–Winter Cover: No Tillage		Winter Grain–Summer Cover: Conv Tillage		Winter Grain–Summer Cover: No Tillage		
Component	GR-	GR+	GR-	GR+	GR-	GR+	GR-	GR+	LSD (p=0.1)
Residue	0.3	0.6	3.6	3.3	0.4	0.9	6.5	2.6	0.9
0-3 cm	4.3	4.3	11.5	11.8	4.4	3.9	11.6	10.3	1.0
3-6 cm	5.8	4.8	9.7	8.1	5.4	4.5	8.2	8.3	1.7
6-12 cm	9.5	10.8	11.5	10.8	10.5	9.8	10.9	11.2	1.8
12-20 cm	13.5	14.3	10.9	9.3	15.5	14.4	7.7	8.8	3.0
Total	33.4	34.7	47.2	43.3	36.3	33.6	44.9	41.3	5.7
Stratification ratio (0-6/12-20)	1.3	1.1	3.4	3.8	1.1	0.9	4.6	3.5	0.6

---------- Implications ----------

- Grazing of cover crops was greatly beneficial to production and had little detrimental effect on soil during 2 years.
- Conservation tillage enhanced cover crop production and preserved surface soil organic C, which led to positive effects on other soil properties, like mitigating compaction.
- Cropping for grain was erratic in summer and consistent in winter-spring during the first 3 years of this study, but there are advantages and disadvantages of both cropping systems that require further investigation.